BOOK DEPARTMENT

Number Work in Nature Study. By WILBUR S. JACKMAN, Cook County Normal School, Chicago, Ill.

This book begins with an address to the teacher, in which the author states that the aim of his work is to show how pupils may be taught to secure through mathematical processes, definite, accurate, and useful results in the study of elementary science. He proposes to frame series of problems, the solution of which will indicate underlying law in the different departments of natural science.

The remarks to the teacher are followed by an introduction in which is discussed the "Relation of Arithmetic to Elementary Science."

The introduction of natural science into the elementary schools will necessitate a reorganization of school studies with a view to making a place for science work.

As the subjects at present on the school program are for the most part indispensable, the place for natural science is to be secured only through a correlation, or concentration, of studies, by which a knowledge of certain subjects may be gained through instruction in other subjects.

All studies may be separated into two groups—*thought* studies and *form* studies, the latter of which may be regarded as a means of expressing the former.

The value of thought study, either as a means of development to the thinker, or for any other practical purpose whatever, is directly dependent upon the readiness, completeness, and accuracy with which concepts are formed. The weakest poir t of the teaching of the present day relates to inaccuracy in the forming of concepts, and, since the function of mathematics is to secure accuracy, hence the necessity for the use of number and arithmetic in connection with science work.

The author refers to the use of mathematics by Kepler, Newton, La Place, and others, and shows that all science must, in a sense, be mathematical.

Adverse criticism is made in regard to the present system of instruction in mathematics, as well as in regard to the careless, desultory work in studies where the mathematical element is lacking. The vagueness and incompleteness of the thinking done

is indicated by such expressions; as, "few," "many," "some," "several," "about," "nearly," "somewhat," " I think," etc. Such work implies a lack of confidence in the knowledge gained, and develops habits of carelessness and inexactness.

The author would have number and arithmetic taught incidentally in connection with the study of natural science, but he is careful to make a distinction between teaching any subject *incidentally* and *accidentally*. The processes of arithmetic must be taught just as thoroughly as when arithmetic occupied a separate place upon the school program.

The plan of study in various departments of natural science is designed by the author to suggest a remedy for the defective instruction indicated in the foregoing discussion. To this end are arranged series of problems in zoölogy, botany, physics, meteorology, astronomy, geography, and mineralogy. The answers to these problems involve the use of number, and arithmetic in integers, fractions, ratio, and percentage. The problems are for the most part arranged logically, and are calculated to lead from the observation of many particulars to the discovery of general truth, *i. e.* of underlying law.

In comment upon the book as a whole, we may say that, at the first glance, it is not prepossessing, but it will repay careful reading. The author has done an important service for the study of the elements of natural science in the elementary schools. Instruction in our schools is defective in general, and in particular; but probably no department of instruction is so defective, and so unscientific, as that of natural science. Very few teachers appear to realize that more is involved in this study than the desultory observation of a few disconnected particulars. Beyond this, a little vague, uncertain work in classification may be attempted occasionally, but, as a rule, nothing is done to afford the pupils a glimpse of even the suggestion of a law.

The author's plan appears practicable for the study of meteorology, astronomy, and some parts of geography. In connection with zoölogy, botany, physics, etc., some difficulty in procuring material for observation, under natural conditions, would probably be experienced. We suspect, however, that the greatest difficulty in managing the book to advantage would be due to lack of proper preparation in the subjects on the part of the teachers themselves. There may be teachers in this country, who are properly prepared to conduct the study of natural science in the elementary schools, but, as yet, we have not seen them at work.

We heartily endorse the author's views in regard to the necessity for the mathematical element in all science work, and we believe that a good part of the work he has presented is excellent, but we do not see that he has done what he claims; viz., to have taught number or arithmetic through the study of natural science. Num-

ber, as a property of the material object, bears the same relation to the objects studied as do size, form, surface, color, weight, etc. Mathematics is a means of exact concise expression, and is put to its legitimate use in being applied to the expression of the thought gained through observation and inference. This is the use which Kepler, Newton, and La Place made of mathematics. Those men did not gain a knowledge of mathematics through the study of physical phenomena, but having mathematics at their command, they were able to express the results gained accurately and concisely.

We very much doubt whether a knowledge of any so-called *form* subject can be gained through instruction in the *thought* subjects. If any real knowledge of it is to be gained, the form subject must in its turn become a thought subject, and must itself become the object of observation and inference.

The difficulty has been heretofore that the knowledge gained from the study of the form subjects has not been put to its legitimate use, *i. e.*, it has not been applied as a means of expression. The author, in his presentation, affords an excellent opportunity for the application of number and of arithmetical calculation, but we are disposed to believe that arithmetic and botany, for instance, were taught separately by him, even though but one was represented on the program, and though the work in both was done during the period assigned to natural science alone.

In the elementary work, children ought to gain such a knowledge of number as will form a foundation for the philosophical concept that lies at the basis of mathematics as a science, and without which advanced work in the natural sciences is impossible. Without presenting number as in itself a thought subject, we doubt whether this can be done, and for this reason, we doubt the possibility of teaching number through instruction in natural science.

One word in addition concerning the work in natural science. The mathematical work here may be overdone. The purpose of the problems is to aid the pupils in determining the characteristics common to a class of objects. This is of course the basis of classification, and is preparatory to the discovery of law. Since the ultimate aim of science work is the discovery of law, any mathematical calculations which do not further this aim are valueless to science and are to be classed with the problems to be found upon the pages of the ordinary textbook in arithmetic.

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